YRKESHÖGSKOLAN NOVIA

# Product Lifecycle Management with W2X

## Development of PLM System for Wärtsilä

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Bachelor's Thesis

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**BACHELOR'S THESIS**

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**Abstract**

Every day, large amounts of information and product-related data are produced. This data are circulated between engineers, experts and project managers. Important information is sent via email, shared via storage devices on the network and often stored on local hard drives. A direct link is needed between the product and product-related data when in need of important data from previous designs and concepts to decrease development time.

The purpose of this thesis is together with the R&D department at Wärtsilä to develop an application that enables storage of product development related information produced in a way that everyone involved can easily see the steps and status of the process developing and maintaining an engine and its components.

By creating an application linked to the PLM system that designers and experts use to support how they work and simplify the process of managing data produced, stakeholders are able to access the product related data created for the product at any given time.

Language: English Keywords: PLM, Lifecycle, Change management

**EXAMENSARBETE**

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Titel: Produktlivscykelhantering med W2X

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**Abstrakt**

Varje dag produceras enorma mängder information och produktrelaterade data. Denna data cirkulerar mellan ingenjörer, experter och projektledare. Viktig information skickas via e-post, delas via lagringsenheter på nätverket eller finns sparade på lokala hårddiskar. Behovet av en direkt koppling mellan produkten och produktrelaterade data uppstår när tidigare producerade data för tidigare design och koncept kan minska utvecklingstiden.

Syftet med detta examensarbete var att tillsammans med FoU-avdelningen och projektgruppen PLM for W2X på Wärtsilä utveckla en applikation som möjliggör arkivering och strukturering av all data som produceras. Detta så att alla involverade enkelt kan se steg och status för processen vid utveckling och underhåll av en motor och dess komponenter.

Genom att skapa en applikation som är kopplad till PLM-systemet, kan alla intressenter enkelt hantera produktrelaterade data vid behov.

Språk: engelska Nyckelord: plm, produktlivscykel, datahantering

**OPINNÄYTETYÖ**

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Nimike: Tuotetiedonhallinta W2X:llä

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**Tiivistelmä**

Joka päivä tuotetaan valtavia määriä tuotteisiin liittyviä tietoja. Tiedot jaetaan insinöörien, asiantuntijoiden ja projektipäälliköiden välillä. Tärkeät tiedot lähetetään sähköpostitse, jaetaan tallennuslaitteiden kautta tai tallennetaan paikallisille kiintolevyille. Tarve suoraan yhteyteen tuotteen ja tuotteisiin liittyvän tiedon välillä syntyy, kun aiemmin tuotetut tiedot aikaisemmista moduuleista ja konsepteista voivat lyhentää kehitysaikaa.

Tämän opinnäytetyön tarkoituksena oli kehittää Wärtsilän tutkimus- ja kehitysosaston ja W2X-projektiryhmän kanssa sovellus, joka mahdollistaisi kaiken tuotetun datan arkistoinnin ja strukturoinnin siten, että moottorin kehityksen ja ylläpidon vaiheet tulevat näkyviin.

Luomalla PLM-järjestelmään linkitetyn sovelluksen, jota suunnittelijat ja asiantuntijat käyttävät heidän työsään yksinkertaistaakseen tuotetun datan hallintaa, kaikki sidosryhmät voivat nähdä luodut tuotteeseen liittyvät tiedot milloin tahansa.

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Kieli: englanti Avainsanat: elinkaari, tuotetiedonhallinta, tieto

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# 1 Introduction

Wärtsilä was founded in 1834 and have for over 180 years been at the front of engineering innovation. The company's vision and ingenuity deliver smart solutions that will keep their customers one step ahead.

Wärtsilä is one of the global leaders in "Smart technology" and sustainable "Lifecycle solutions" for the energy and marine markets focusing on efficiency, data analytics and sustainable innovation. Wärtsilä is maximizing the economic and environmental performance of both vessels and powerplants for its customers. Wärtsilä consists as of January 2019 of two primary businesses, Marine business and Energy business. Service business have been merged into both Marine and Energy business.

## 1.1 Marine Business

The Marine business is focused on enhancing its marine and oil and gas industry for the customers by providing solutions and products that are safe, environmentally sustainable, flexible, efficient and economically sound. By being a technology leader, having know-how through the experience and being dedicated to its personnel, Wärtsilä can create custom solutions that will provide benefits to customers around the world.

## 1.2 Research and Development

The focus for the R&D department is on smart technologies, new products and solutions that are flexible, efficient, reliable and cost-efficient to operate. It is essential that they impose a very low environmental impact. By concentrating on the initial stages of the development process, utilising modularity, simulation, testing and validation, new solutions is achieved.

## 1.3 Defining the Challenge

The purpose of this thesis is to help develop an extension of the existing Product Lifecycle Management system currently in use at Wärtsilä, to organize and connect daily produced product data related to the model in order to eliminate data loss and reduce time searching for previous reports. Furthermore, the goal is to also reduce the risk of information only available by a single expert. Great problems may arise if an expert retires, switches position or is laid off and that person's information has not been stored anywhere or shared.

Currently the flow of information consists of a document-based system. A document-based system is working like a chain. Information is passed on from one department to another via e-mail, verbally and including links to documents on network storage. Using this system is effective at the moment, the relevant information is sent to the department involved. However, the risk of breakage in the chain is ever present and traceability is minimal. In terms of possible future needs, the information is easily lost in the e-mail inbox or on the network storage, in the worst case on a local hard drive.

There is a suggestion to move to a model-based system that uses a central hub where all information is stored and organized and which connects the related product data to a specific product. Even if the product data is stored on a network storage, there is a link to it via the product. This hub would be accessible by any involved department to view and have access to the product related data.

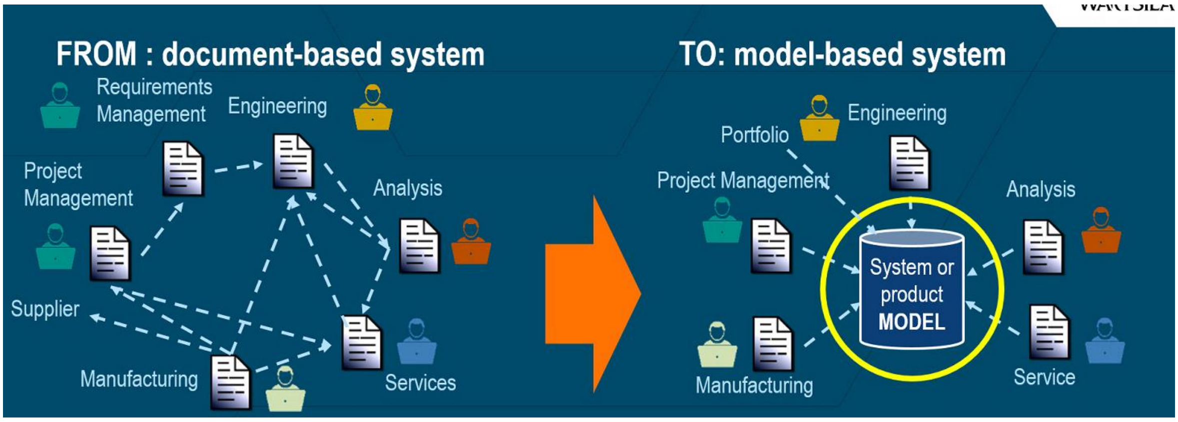


*Figure 1. Illustration of the flow of information within Document-based system and Model-based system.*

The project, named W2X is a new small-bore engine currently developed at Wärtsilä. By working with W2X the Product Lifecycle Management project can analyse how data and design concepts are produced, determine how to organize and connect design and product related data.

**The plan:**

- Take a role in the "PLM for W2X" project and the W2X project.
- Act as a "**middleman**" between the PLM and W2X projects.

- Investigate activities (meetings/workshops/design studies) done in the W2X project.
- **Analyze** the data on how it fits in the Product information model.
- **Propose** solutions for archiving in PLM
- **Execute** the archiving of W2X product data as specified by the Product Information Model.

### 1.4 Restrictions

Focus is on the product lifecycle management more than systems engineering even though the way of working developing this software is systems engineering. This is because the goal is to improve the current PLM system even though engaged in systems engineering by identifying functionality needs for the engineers at R&D and other problem-solving focus was the flow of data.

## 2 Product Lifecycle Management

Product Lifecycle Management or PLM for short is a collection of different sub managements, product data management (PDM) and engineering data management (EDM). EDM and later PDM was created during the 80's for engineers to keep track of their designs since the Computer-aided Design (CAD) systems became available and allowed the designers to produce more data. PDM allowed them to standardize and control items, control and store documentations, update their bill of materials and see the relationship between parts and assemblies. (Saaksvuori & Immonen, 2010, pp. 1-2)

### 2.1 Definition of PLM

Product lifecycle management is a systematic and controlled managing and development tool for product development and related information offering control of the product and related information throughout the whole product's lifecycle, product development, product marketing, distribution and service. The core of PLM is product related information and activity storage to ensure a fast and easy traceability of the data for daily operations. (Sääksvuori & Immonen, 2002, pp. 18-19)

PLM has a wide range functionality and concept of a systematic method for storing and controlling the product information described earlier. The main function is to steer and control the way data is produced, designs created, how to handle and store product related data and activities throughout the life span of the product. "Kenneth McIntosh, according to Sääksvuori and Immonen, defines PLM (then EDM):" *PLM is a systematic way to design, manage and control all information needed to document the events of a product throughout its lifespan. This includes planning, design, development, production and usage"*. (Sääksvuori & Immonen, 2002, p. 18)

Regardless of when or where the information related to the products was created it should be easily retrievable and reusable in every situation needed. This allows for quicker responds in support calls and requires less time and labour. PLM can help in reducing the cost in companies when less time is used searching for the right information since the part and related information is connected. A good lifecycle control also gives an opportunity to remove faulty products and increase the revenue boost by concentrating on innovative products. (Sääksvuori & Immonen, 2002) (Saaksvuori & Immonen, 2010)

## 2.2 Production Lifecycle Management Systems

Product Lifecycle Management is used in companies for different reasons, depending on which branch of the organization that is involved, the kind of product it produces and what the company wants the system to achieve. PLM systems create useful problem-solving tools and ways of working to manage every-day product data and product lifecycle management issues. Bear in mind that the systems is not going to solve everything by themselves. For one company the PLM system are just a tool to effectively do daily business, for others it is a way to take over international markets by doing investments. (Saaksvuori & Immonen, 2010)

PLM is constantly being developed and more and more companies are implementing it. The reason for this is the complexity and large amount of data being produced everyday by creating and maintaining deliverable products. The competition increased globally requires faster production, lower costs and tailormade solutions to customers. Companies are constantly looking for solutions to solve their daily issues. Customers expect an advancement in technologies from products. Because of this the production and even products have become more complicated even if it would have been possible to simplify the product by developing the production process and design. (Sääksvuori & Immonen, 2002, p. 13)

Development of product quality and production processes is vital in competing internationally. Increasing quality standards requires planning and product development processes where information is effective, reliable, correctly archived and utilized. If a company wants to push their products onto the market faster, efforts in the development departments must be concentrated to the planning stage. Companies operating over many networks must be able to do changes to a product and find related data in a short time. Communication that is reliable and effective is required. Using PLM systems can be the solution. (Sääksvuori & Immonen, 2002, pp. 13-14) (Saaksvuori & Immonen, 2010)

## 2.3 Integrating other applications to PLM systems

A PLM system is a vital part of the infrastructure in an industrial company. Implementing a PLM system does not necessary replace the existing system but adds value to it. The value comes with new functions, properties and possibilities of PLM, allowing manual processes to become electronic. (Saaksvuori & Immonen, 2010, p. 53)

Integrating a new system is often a difficult and laborious part of the process of implementing PLM systems. Decisions for what kind of information is uploaded by each system is vital. The design of relationships between other systems and PLM requires a lot of consideration. Systems include for example:

- Computer-aided design systems (CAD)
- Document management systems
- Enterprise resource planning system (ERP)
- Reporting systems
- Office applications
- E-mail systems

- Other applications like Browsers, image editors and bookkeeping.

Integrating everything into a PLM system is not a necessity but worth consideration if a management tool can be useful when integrated to the system. (Saaksvuori & Immonen, 2010, pp. 53-54)

Applications acquire the information it needs via two methods; sharing and transfer. These methods differentiate from each other by the way information is copied. Sharing involves usage of a central database while transferring information is copying the information instead of moving the information. (Saaksvuori & Immonen, 2010, pp. 54-55)

Usually it is easier to transfer information rather than sharing it. Sharing information requires exact knowledge of how the software is structured and often requires tailor specific programming to be able to communicate properly. For transferring information, on the other hand, it is problematic to ensure that later changes are updated into the database. Transferring information is more suitable for communications between separate companies or organizations. Sharing information is most suitable inside the company, within tightly integrated applications. (Saaksvuori & Immonen, 2010, p. 55)

## 2.4 Managing Changes

PLM emerged as a result of managing products and product data became very complex and the working environment underwent frequent changes. Most organizations and companies would be grateful if there were no changes in the world of production environments. It would be easy to get organized and produce to customers as efficiently as possible the same product repeatedly. However, in present day change in production is inevitable (Stark, 2011, p. 17)

PLM often results in changes being proposed. Whether it is due to PLM or other reasons people usually resent change and this causes difficulties for companies. PLM is to begin with, a complicated activity to implement changes to, since there is nothing physical to work with and often little information of how to do it in practise. Rather than optimizing the PLM system, cutting down time-to-market and increasing sales companies often focus on introducing a new application for their system. (Stark, 2011, p. 311)

Change is often very difficult, costly and time-consuming. To successfully implement or optimize PLM it will, however, be necessary. Initializing the change, companies often get caught between greed and fear. The benefits of change are tempting but the fear of failure is great. When companies are standing in front of a big project, they make sure they have a clear objective, specifications, project team and manager and a plan of action. The same must be done when going through a major change, else no change is going to be made and then the company reverts to how they were doing in the beginning. (Stark, 2011, p. 312)

## 2.5 Challenges with PLM

The problems occurring in daily business in PLM become evident in three typical areas:

1. The concept of Product lifecycle management with all acronyms and terms can often be unclear and undefined. For example: “What is PLM and its purpose?”. This results in that the connection between information and product becomes unclear and utilizing the product information for maximum potential becomes complicated. (Saaksvuori & Immonen, 2010) (Sääksvuori & Immonen, 2002, p. 18)

2. The way information is created, used and how it is stored may vary depending on the organization. Information is produced every day with a purpose and in a certain context. This information should however be able to be used in another context outside the original task it was produced for. The lack of a system with an integrated documentation process requires manually filling in the product structure. (Saaksvuori & Immonen, 2010, p. 9)

3. The consistency and completeness of the information produced in different departments or companies cannot be guaranteed. This occurs when product data is stored in different medias or even in paper form and different parties have a different approach on how to handle the information. Other shortcomings can occur when the agreed upon storage is not being used properly and documents and files are being stored locally on a computer or in an e-mail. From then on no one is certain if the uploaded file is the absolute latest version. (Saaksvuori & Immonen, 2010, pp. 9-10) (Sääksvuori & Immonen, 2002, p. 18)

To avoid these issues and situations updated systems for information processing supporting product lifecycle management should be used. Systems for information processing have evolved massively during the years and even if all the issues have not been resolved yet, practical errors, different software used by different organizations, different way of working, the way PLM is implemented and used is more integrated nowadays and carried out almost without exceptions. (Saaksvuori & Immonen, 2010, pp. 10-11)

# 3 Systems engineering

Systems engineering is defining, developing and deploying systems. Systems engineers consults with the users and implementation specialists, who later will produce the system, concerning the function of required system. Systems engineering is an organizational, technology-based human effort. Usually systems engineering is dealing with systems that are massive in scale and in a large scope. These systems can be quite complex, containing many different parts related to each other in complicated ways. (Sage & Armstrong jr, 2000, pp. 2-3)

Often the systems engineer builds a simplified model of the proposed project to test and refine ideas. Testing in small scale with prototypes can be both cost and time efficient, they allow testing on a synthetic system rather than using the real large-scale system. Systems engineers analyse and try to understand complex situations and they are often called upon to evaluate and develop policies and programs. (Sage & Armstrong jr, 2000, p. 3)

Systems engineering can be associated with management technology. Technology is the application, organization and the delivery of information. Technology requires human actions and then enhances the abilities of humans to calculate and process information. Information is highly valuable when facing decision making. When data and information relate to context it becomes utilizable knowledge. Management involves interaction between the organization and the environment. One of the main purposes of management is to help organizations achieve goals and tasks in their environment. (Sage & Armstrong jr, 2000, pp. 3-4)

To create a functioning system, an understanding of what functions must be fulfilled by said system is needed. Depending on how complexity and the scope the engineering of functions will vary. The engineer’s role will change from situation to the next, consulting or system designing, but in every phase of the process, engineering functions in one way or another is performed.  (Blanchard & Fabrycky, 1990, p. 55)

No matter the size or type of system, first a need must be identified, research the purpose, requirements established, constraints and criteria of the design. Based upon the results, functionality is analysed, and system levels are generated down to sub-systems and lower levels of the system. By analysing different approaches, the outcome should be reflecting the preferred feasible system meeting the identified need. (Blanchard & Fabrycky, 1990, pp. 55-56)

# 4 Robotic Process Automation

Robotic Process Automation can be defined as a digital workforce, a robot that performs daily manual tasks. The robot works as an own user in existing systems and further integration and implementation are not needed. A Robotic Process Automation (RPA) allows anyone to configure a computer software or robot to emulate human actions, capture data and manipulate applications. RPA’s can communicate and trigger responses with other systems to relieve the user from performing repetitive tasks. Unlike humans, RPA’s do not make mistakes, sleep and are cost efficient.

# 5 Information processing systems

Wärtsilä uses a wide array of software to process information produced by the different internal departments, each with their own purpose to store a unique kind of information. Many of these are connected and can directly send information and data between each other. Some, however, are not compatible and require further action to import and export data within the system.

## 5.1 Teamcenter

Teamcenter® software, developed by Siemens, is an adaptable and modern product lifecycle management (PLM) system. From the multifunctional user interface users across the organization can join the development process easier than before. Teamcenter is controlling the product data and processes, including software, designs, assemblies, bill of material and electronics. Teamcenter is flexible and able to adapt to business changes and manage the challenges of product development.

## 5.2 3dExperience

The 3DEXPERIENCE® is a business experience platform developed by Dassult. Providing software solutions for every organization in the company, extends from marketing to sales to engineering, that ease the creation process to make differentiating consumer experiences. With a single, easy-to-use interface, 3dExperience powers Industry Solution Experiences, based on 3D design, analysis, simulation, and intelligence software in a collaborative. 3dExperience allows designers to use simulation during the daily design phase covering fluids, vibrations and structural integrity. The process of simulation of items can be captured and exported to be utilized in later processes.

## 5.3 Polarion

Polarion introduced the first browser based ALM (Application Lifecycle Management) enterprise solution back in 2005. Built from the ground up pioneered the concept of multi-directional linking of work items allowing full traceability, accelerating productivity. Polarion allows integration between PLM and ALM, filling the gap between mechanical, electrical engineering and software development. Polarion functions as a high-level task management tool to track progress and status of projects.

## 5.4 Palma

PALMA®, Product Architecture Lifecycle Management by Modular Management Group, allows the creation of personalized systems to document and oversee product architectures. The platform is giving the user high performance and complete history. Everything is made possible through unique data models powered by a futuristic database technology. "*Unique Configuration Intent*™ "enables easy configuration modelling.

## 5.5 M-files

Document management tool M-files is an intelligent information management platform that organizes documents depending on content rather than where it is being stored. M-files can be connected to existing systems and network folders and optimize them with built-in AI and is able to categorize and secure information. The program's intelligent management solution is based on metadata and is repository neutral, allowing you to see information in context regardless of system of origin.

# 6 PLM with W2X

PLM with W2X is a project that started back in 2016 to support Wärtsilä with the intent to ease the traceability of the development done on modules in the R&D department and then later in all design departments of Wärtsilä. Easy access to previously stored data is critical when production has been ongoing, and engines need service.

By using the PLM with W2X program finding the right component saves time otherwise spent calling or emailing the developers who struggles to remember the reason why a specific version of the component was used. This traceability also saves time for the R&D department when the next generation of engines are to be developed and solutions to issues solved on previous project are found with ease, thus allowing easy implementation of the same kind of solution on the ongoing project.

## 6.1 Investigating activities

Creating and developing a software with functions required by the R&D teams, requires information to be collected and defined. Every team have their own way of working to efficiently produce concepts, data and numbers. This way of working had to be taken in consideration when designing the new software to not make the new methods require more effort than before. This required studying the team's work methods, following the meetings and discussions of the different task teams as well collecting and sorting what they were producing.

Every team creates designs of a concept for the modules the team is developing. Designs are discussed within the team with experts and solutions are proposed. Depending on the cost, material or design-conformity a decision is made on how to move forward.

Keeping track on the progress, upcoming tasks and issues, slideshow reports are updated and presented to the project team and experts. The slideshows are primary place holders for all the information the teams are producing during the development and are constantly updated and referenced to. Mentioned slideshows also function as a visual aid to stakeholders and project managers showcasing if the teams have enough resources and time to meet deadlines and estimate when the engine will be ready to be put into production.

## 6.2 Collecting the data

The first phase of the project PLM for W2X required a follow up on the progress of the different teams that were developing the new engine. Different teams are concentrated on different sections of the engine and further categorized into different modules. These modules became the primary target for data collecting. Every module is containing several different parts and if the focus were on every individual part within the module the amount of data needed to be collected would be unreasonable big and difficult to structure as well as hard to review when needed.

For deeper investigation a single module was targeted, researching data related to the module development. Tracing back to early stages and concepts, researching changes made to the module and the reason behind changes. By reviewing meeting reports a basic understanding of the evolution of the module was available. However, changes due to simulations and design non-conformity with other components required interviewing the developer and task team leader. All data exists but the way data is being stored and handled is not easily traceable.

## 6.3 Structuring the data

To create an easily understandable visual overview, a tree structure was created. A tree structure of the component shows when changes were made and adding a short explanation for each change. These explanations reasons for the changes, such as simulations or simply design non-conformities, for the change and what has been done and the results of that change.

By creating a structure of the changes made to a module or component you can easily track what has changed when and why. The reason behind the changes is stated next to each concept to easily follow why this module is not ready for release.

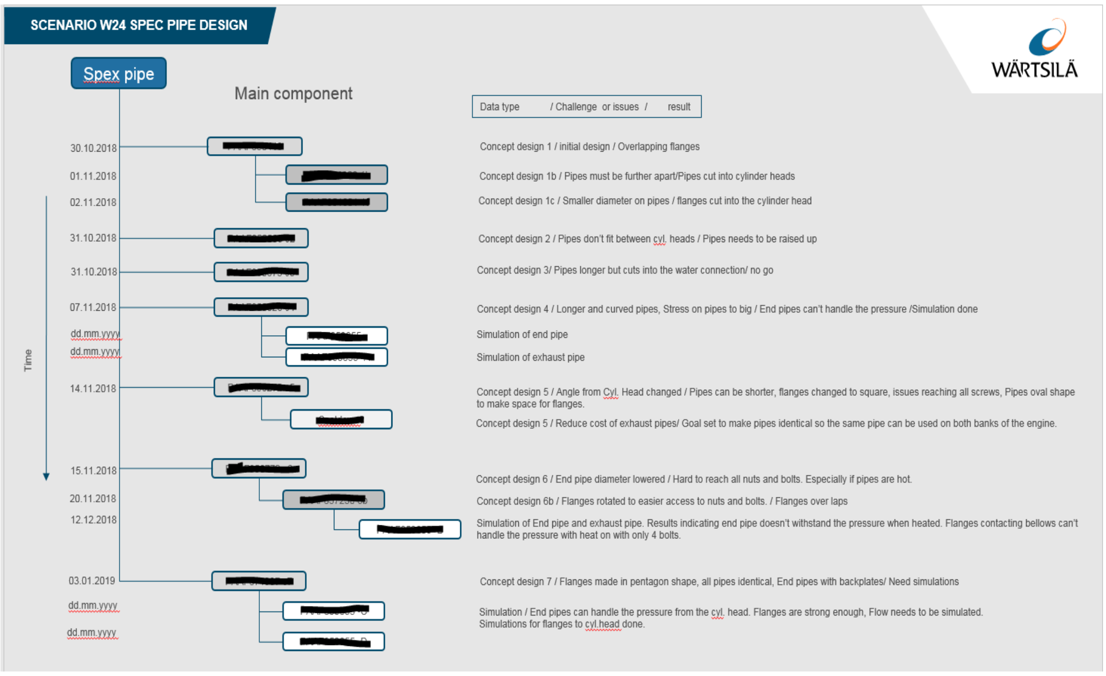


*Figure 2. Structure tree of different concepts created for the followed module.*

## 6.4 History viewer

Using the collected data and structure a prototype timeline was created. The history viewer prototype created by eCraft required a manually uploaded Excel file containing all data. The Excel file template was configured and rewritten with the existing design concept data and then uploaded into the history viewer. This viewer created a timeline showing when a concept was made and the decisions and calculations around it.

Further expansion to the timeline, such as links to related documents such as simulations and calculations, 3D model viewer or snapshot of the component, needed implementation. A suggestion from the PLM team was that rather than using slideshows the history viewer would serve as a medium for future planning and showcasing previous tasks. The prototype timeline is shown in attachment 1.

The timeline was only one part in the progress for better archiving of data produced by the engineers. A tool developed to help the engineers to better capture and automatically sort the data and draw the timeline without manually filling in an Excel document. This tool would be the core of keeping track of each component and any relevant information, such as the creator, timestamps and possible comments.

## 6.5 Change-management Tool

Change management tool (CM-tool) is an application that is being developed to allow traceability of a design and related information for future problem solving or status reporting. The application serves as a user-friendly browser-based tool connected to Teamcenter submitting and retrieving data from the PLM system.

The CM- tool enables users to take part of the process of module development and see the progress that has been made without being forced to search for the information located in an e-mail, someone's local hard drive or a file in M-files. The tool is created with the purpose to display, with the assistance of a visual timeline, how the modules are evolving throughout the developing process and showcase simulations, calculations, changes and the reasons behind them.

Not everyone working at Wärtsilä or with the project are using Teamcenter. Some experts and those who create calculations or simulations mainly use Microsoft Excel to create simulations using numbers, dimensions and materials to determine if the component is fulfilling the requirements. These calculations or reports are not saved into Teamcenter and more often not linked to the component. Currently the reports get saved as their own slideshows and only the critical data is imported into the Power Point presentations of the task team during meetings to discuss the next step of the process.

To ensure that the data (simulations and reports) gets linked to a specific design the CM-tool will enable the user to submit the report of a design and will link the document to the design in Teamcenter. This enables work related to components done outside the network of Teamcenter to be saved and linked to the project and accessible by interested parties. This is done by robotic process automation (RPA) to ensure the document is stored under the right conditions in the right location.

## 6.6 Change Requests

Change request is a function within Teamcenter that primarily serves as a task management tool. The group leader can create a change request for a designer to alter and improve a design for a specific component. Via this change request the submitted design will be sent for approval and released into production.

For this project, however, the change request is reworked to function as a bus for data. The change request allows the CM-tool to collect data produced by the task teams and organize, connect data and create timelines. By using RPA (Robotic Process Automation) the user does not have to manually set up change request to capture the data, which would involve careful set up in many steps and consume time.

The manual set up for a change request is here listed step by step:

1. **Create requirements**.
   This includes the main needs and requirements from an engine and the components building up the engine, emissions, effect, market specific needs, and on lower levels modules requirements. These requirements were defined in the beginning of W2X.

2. **Create change request.**
   Change request are made in Teamcenter as a new item. Going to File, new change request. Define for which engine the request is for as well as for which module. The request needs an owner and changer. The owner can be the task team leader and the changer are the responsible designer of the module.

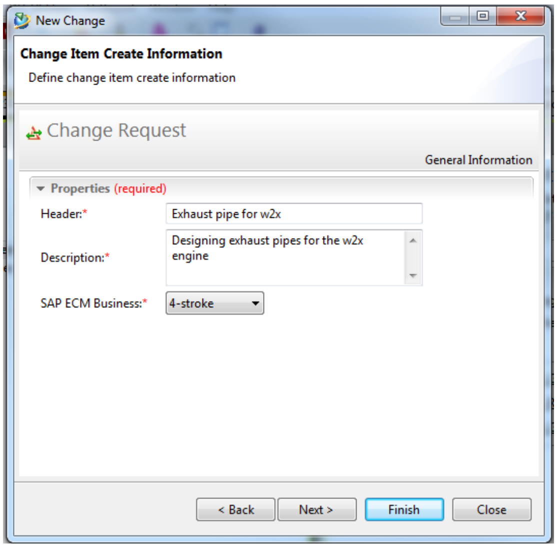


*Figure 3. Creating new change-request.*

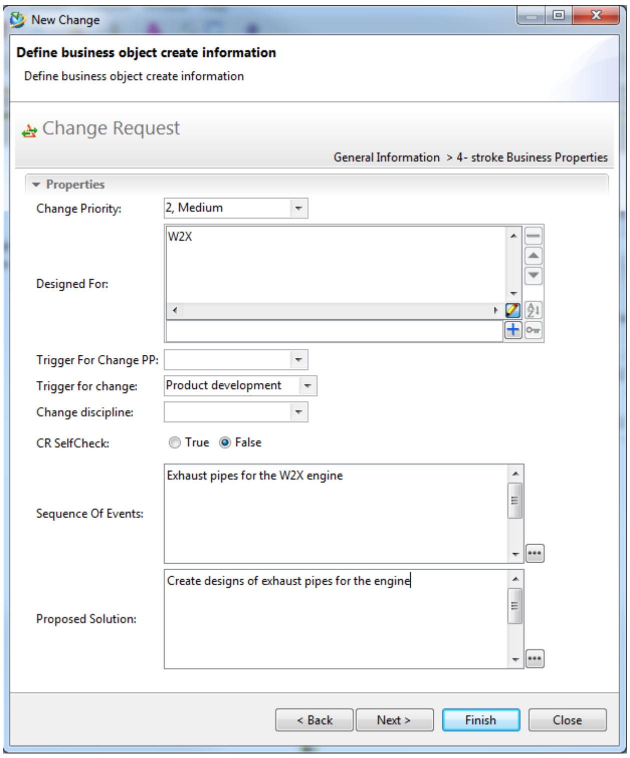


*Figure 4. Define what the request is for*

- Add requirement to problem items folder of CR.

  Create a document item type and add the requirements defined in point 1 as a document.

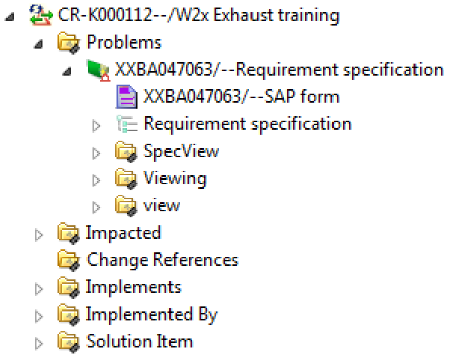


*Figure 5. Requirements added to problem folder*

3. **Create solution item.**

   Solution item can be defined as a component design, such a model of an exhaust pipe.

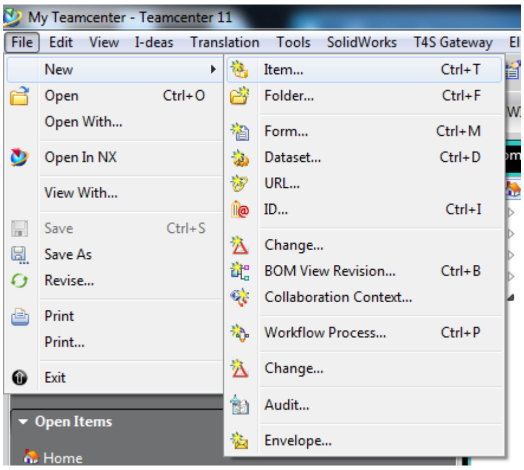


*Figure 6. Create new item*

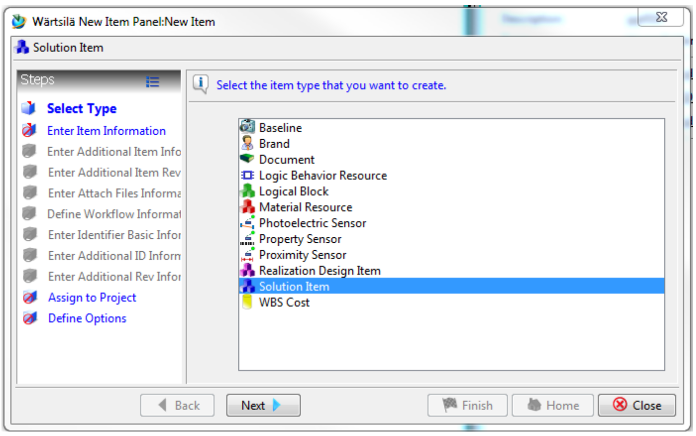


Figure 7. Create solution item for the component.

- Add classification and select module (and design group), the solution item takes the classification name.

- Add the solution item to the “impacted items folder”.

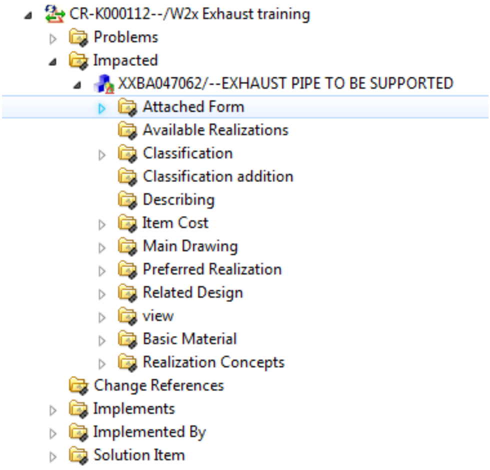


*Figure 8. Add the solution item into impacted folder.*

- Create plan item and add a task approach, the "plan item" is not yet implemented into Teamcenter, then add the plan item into "plan item folder" of the Change request.

4. **Create design concept**.

   Design a model and/or create an assembly of the module in question.

   - Add the designs to pseudo folder "realization concepts" of the solution item.

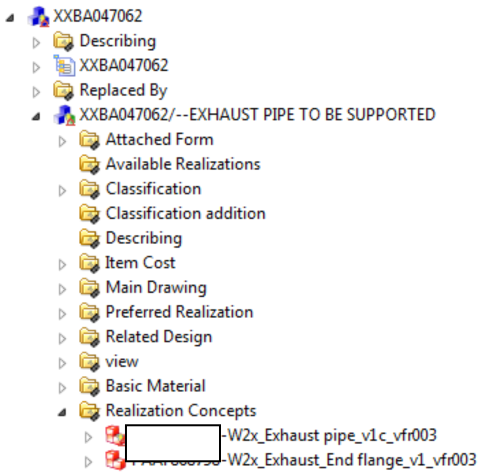


*Figure 9. Add design into the folder "Realization folder" in the Solution item.*

- Add all concept designs to "solutions items" of the Change request.

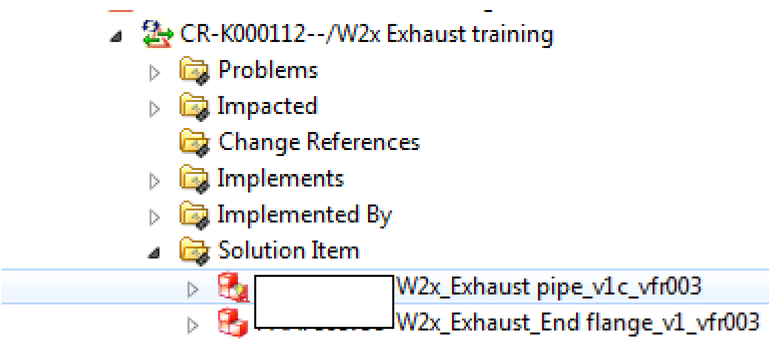


*Figure 10. Add designs into the folder "solution item" in change-request.*

- Add designs to "realized deliverable" of the plan item.
- Capture review result and/or simulation results to the "Design validation" folder, found under the design item, of the concept designs.
- Add the review results to "Solution items" of the Change request.
- Add the review results to the "design review" of the plan item.

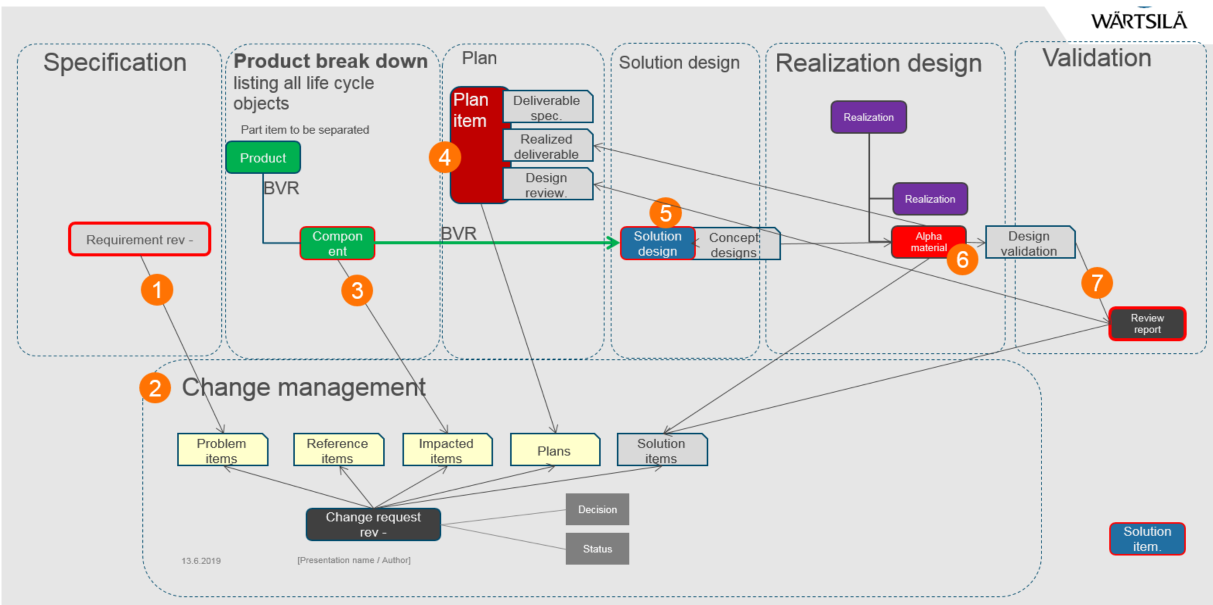


*Figure 11. Early wire diagram of creating a change request*

Manually inserting and creating every item to create this change request is not user friendly and a daunting process. Since this process must be quick and easy to operate it was decided to use Robotic Process Automation (RPA) to handle the process of creating the change request and only selecting the newly created designs or documents into the change request is left to the user. By using an RPA, the risk of creating a mistake in the creation of a change request is minimized by eliminating human error.

# 7 Results

Different configurations to manually set up the change request were tested and missing components in the PLM system defined. Gradually missing items were implemented into the test environment and further tests of change requests were done. Methods for setting up a change request changed slightly when new item types were implemented into the test environment. Testing with engineers at R&D targeted in July with actual data when the planned release of browser application is due.

Teamcenter requires further updates to be fully integrated with all the different systems in use. Teamcenter is versatile on that point that it can be programmed and expanded to be able to communicate with many different applications. With the RPA's, currently in test and development, the process of saving product information into M-files and later connect product data to products in Teamcenter will be automated.

The first alpha release of the CM-tool was scheduled in late July 2019 and required manual creation of the change requests. A team of testers will run the tool and provide feedback and suggestions for improvement. Upcoming tasks will be creating training material and hold training sessions for the teams and start up the process of "saving the data".

# 8 Discussion

PLM with W2X project is a very complicated project. The magnitude of parts and components created to manufacture an engine made it complicated to know what data was needed to be stored and be retrievable for future needs. By focusing on collecting data related to the modules that the engine is divided into the data become more manageable.

The progress of the CM-tool was very slow, this due to the need of convincing stakeholders and further investors. The cost for developing this tool became higher than anticipated and negotiations with different developers occurred. This halted the development of the tool for a while but during this period more focus were laid on testing change request processes and introducing RPA's.

When there was no visual aid and no physical product to showcase it was difficult to inspire and motivate the teams of R&D to take part in the development of this tool. In the end the timeline was impressive but scared the engineers because of the lack of information about the project. Being the middleman between the PLM project and engineers at R&D, it was troublesome to showcase and sell the project when the only material available was wire-diagrams and bullet points.

The relevance of “saving data” varies depending on the circumstances. Some may argue it is never relevant because their work is based on present circumstances and challenges. One could say connecting products and product related information takes too much time. However, this kind of thinking is short sighted, as the information might not be relevant until a couple of years have passed and might be more valuable for another department, like service department.

By exercising proper archiving no one is relying on a single person, such as the one expert who knows everything about a specific part of the engine. Relying on a single person to have the information is dangerous and losing valuable information is as good as unavoidable. Therefore, with a little more effort valuable information can be saved from being lost, not for you but for the rest of the company.

The project management of W2X requested a presentation to the engineers at R&D and other experts. Response was divided yet partaking since organizing and connecting products and product information is in dire need. Concerns of who were supposed to spend time creating these requests so the program could draw up a timeline. As well as most were agreeing on this kind of system is absolutely needed. People do not welcome change as mentioned by Stark (2011).

If I were to continue working for this project, I would focus on releasing the alpha version of the CM-tool as soon as possible for the engineers to play around with. To see the RPA’s in action and come to grips of how the tool is working and looks like. It is hard to give inputs of improvements if they are unfamiliar with the tool and its functions. We, in the PLM project, knew what was required by the tool but how the tool executes and performs actions is still up to the users to perfect.

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# Attachment 1